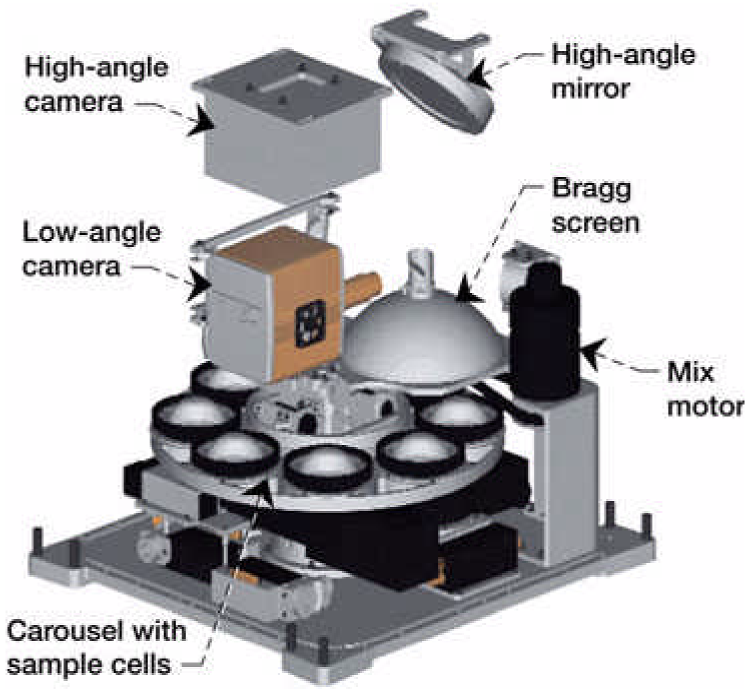
Physics of Colloids in Space: Microgravity Experiment Launched, Installed, and Activated on the International Space Station

The Physics of Colloids in Space (PCS) experiment is a Microgravity Fluids Physics investigation that is presently located in an Expedite the Process of Experiments to Space Station (EXPRESS) Rack on the International Space Station. PCS was launched to the International Space Station on April 19, 2001, activated on May 31, 2001, and will continue to operate about 90 hr per week through May 2002.



Physics of Colloids in Space (PCS) test section features.

Long description Illustration showing carousel with sample cells, low-angle camera, high-angle camera, high-angle mirror, Bragg screen, and mix motor.

PCS is concurrently gathering data on the basic physical properties of three different types of colloids to study how colloidal structures grow, the rates at which they grow, and the structures that they form. A colloidal suspension consists of fine particles (micrometer to submicrometer) suspended in a fluid, for example, paints, milk, salad dressings, and aerosols. The long-term goal of this investigation is to better understand how colloidal constituent properties affect the properties of a bulk colloidal suspension and to begin to probe the unique light-scattering properties of nanoengineered binary colloidal alloys. The potential payoffs of PCS are improvements in the properties of paints, coatings, ceramics, and food- and drug-delivery products; improved manufacturing of products requiring either colloidal suspensions for processing or as precursors; and important first steps in the research and development of an entirely new class of materials that can passively affect the properties of light passing through them. These materials may find uses as optical switches and lasers for advanced communications and displays. This experiment is the first part of a two-stage investigation conceived by Professor David Weitz of Harvard University along with Professor Peter Pusey of the University of Edinburgh.

Colloid polymer critical point sample--13 hr, 24 min after being mixed. Sample shows a phase separation never seen on Earth.

Long description The Colloid-Polymer Critical Point sample is a combination of monodisperse PMMA particles and polystyrene polymer, suspended in cis-decalin and tetralin. This sample was homogenized on July 17, 2001. Immediately after mixing, it began to phase separate, or demix, into two phases--one that resembles a gas and one that resembles a liquid--except that the particles are colloids, not atoms. In this image, the black regions (colloidal gas) are bigger and the white regions (colloidal liquid) have become whiter as the domains have coarsened.

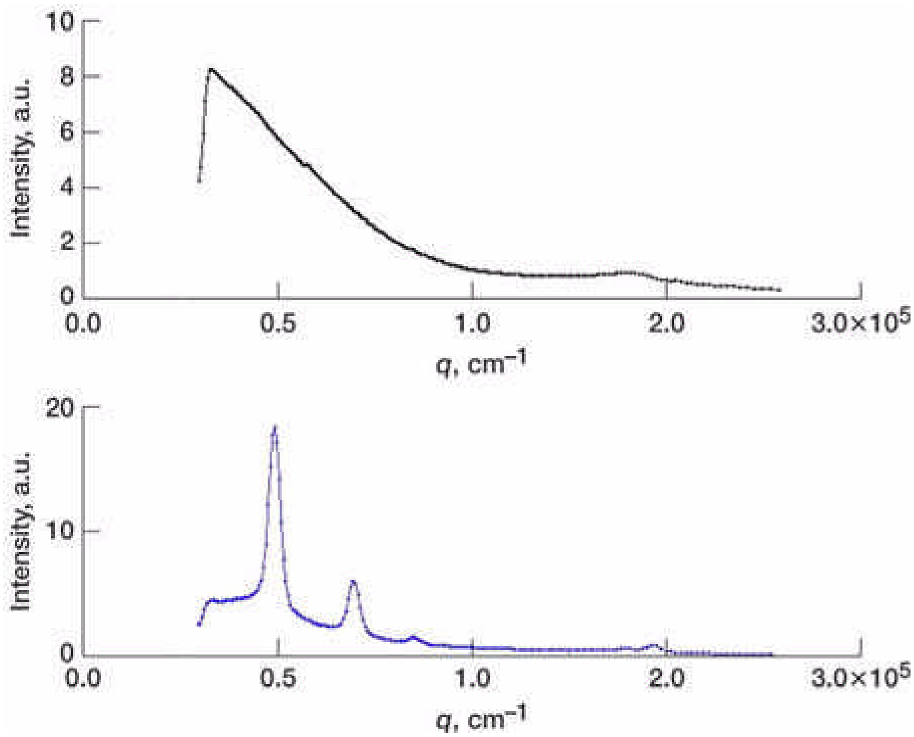
AB6 binary colloidal alloy sample--20 days, 11 hr after being mixed. Bands of color can be seen that were created by the diffraction of white light by the crystallized sample.

Long description The AB6 binary colloidal alloy sample is composed of two different sizes of monodisperse PMMA particles, suspended in cis-decalin and tetralin. The sample is referred to as AB6 because, upon crystallization, the fundamental crystal lattice structure that is observed is 6 B (smaller) particles surrounding 1 A (bigger) particles. The AB6 sample was homogenized on June 29, 2001. From the onset of mixing, the sample began crystallizing.

PCS contains eight approximately 3-milliliter colloid samples, each contained by a glass cell stationed within a remotely controllable carousel inside the PCS test section. Experiment operations consist of mixing (or homogenizing) the colloid samples to eliminate any sedimentation and to produce a uniform distribution of particles in the solution. Once mixed, particles start to self-assemble, and the diagnostic measurements are initiated. Measurements are regularly made on each sample over 1 to 2 months as its substructures (either crystallines or gels) grow and evolve. Measurements include still color digital images, high-angle static laser light scattering (or Bragg scattering), low-angle static and low-angle dynamic light scattering, fiber static and fiber dynamic light scattering, and rheology. The diagnostic data provide growth information, the shape of the structures formed, and other physical properties of the structures.

PCS is being remotely operated from the NASA Glenn Research Center's Telescience Support Center in Cleveland, Ohio, and at an established remote site at Harvard University in Cambridge, Massachusetts. The two locations permit daily remote operation of the experiment. In real time via commands uplinked from Earth to the International Space Station, the PCS commanders control such activities as which sample to interrogate, when to homogenize the sample, which diagnostic technique to employ to perform the interrogation, as well as the sequencing of sample diagnostic runs.

PCS completed its checkout operations on June 22, 2001. During the subsequent 13 weeks, it did an initial survey of crystal nucleation and growth on six of the eight samples and then reinitiated more detailed investigations on the two binary colloidal alloy samples. The crystalline samples (AB6, AB13, colloid polymer crystal, and colloidal glass) are all behaving as hoped for, with the growth of the crystallites having been interrogated by a host of different state-of-the-art light-scattering techniques. The colloid polymer critical point sample, as hoped, exhibits, upon homogenization, a phase separation, or demixing process, that would never be seen in 1g. The colloid polymer gel sample, the last of the six samples to be homogenized, was verified to gel in microgravity, and aging of the gel was observed. Each of these six samples is to be rehomogenized to enable more detailed investigations to occur over the upcoming months on orbit.



Diffraction patterns from the AB13 binary colloidal alloy sample (high-angle scattering). Intensity shown in arbitrary units; q is directly proportional to the scattering angle. Growth of Bragg peaks over time indicates the presence of crystals. Top: 0.48 hr after melting. Bottom: 255 hr after melting.

Long description High-angle scattering diffraction patterns of the second binary colloidal alloy sample, AB13. After the sample was melted, the scattering was fluidlike. Then Bragg peaks appeared about 7 days later. By following the growth of the Bragg peaks over time, researchers monitor the crystallization process. High-angle scattering is performed with a laser, a Bragg screen, and a high-angle camera.

Overall, the initial survey was successful in determining the crystallization time and other characteristics of the samples, revealing exciting areas of interest for each and confirming the diagnostic techniques to be used for the much more detailed measurements to be conducted on each sample through May 2002. Two samples yet to be interrogated, composed of colloids that gel in an irreversible manner when a salt is added, will be initiated during future PCS experiment runs. To date, experiments performed by PCS have proceeded very well with the instrumentation exceeding Professor Weitz' expectations. The PCS experiment was developed and launched and is being operated by Zin Technologies under NASA contract NAS3-99154.

Find out more about this research:

Glenn's PCS research (includes data on a sample-by-sample basis--being updated)
http://microgravity.grc.nasa.gov/6712/pcs.htm
David Weitz at Harvard (introduces the principal investigator)
Principal investigator group at Harvard (scientific focus areas of interest)
http://www.deas.harvard.edu/projects/weitzlab/

Glenn's microgravity research http://microgravity.grc.nasa.gov/
Glenn's fluid physics research http://exploration.grc.nasa.gov/life/

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